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Towards transformative social learning on the path to 1.5 degrees

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This paper provides insights into learning orientations and approaches that encourage change and transformation on the path to achieving the 1.5 degree C target. This literature review of the climate change and education/learning interface positions relevant literature in a heuristic tool, and reveals different learning approaches to addressing climate change. We highlight that although traditional lines of departure for achieving climate targets are usually technocratic in nature, especially if a zero emissions pathway is aimed for, there is an increasing realisation that climate issues are complex, deeply intertwined with unsustainable development and cultural change, and require collective engagement. Through considering the 1.5 degree C target as a metaphor for the fundamental changes needed in society, we argue that a wide range of learning orientations, including more inclusive and transformative social learning approaches, are needed to address the colossal challenges facing society.

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Introduction

Education and learning play a leading role in human development and societal transformations [1••], including climate change, with the IPCC [2] highlighting the need for learning-centred transformation in climate change adaption. Yet in an increasingly polarised and value saturated context of climate change disagreement [3] it is unclear what different orientations of learning there are, and how different learning approaches can inform the pathways to 1.5 degree C.

The 1.5 degree C target agreed upon at the Paris climate change summit is often perceived as a technical goal to be achieved through transformations in, for instance, energy production and carbon storage technologies [4]. This is closely connected to a focus on political will in closing the gap between science-based targets and national commitments [5]. Within this socio-technical genre of thinking, education can also be technically 'used' along with communication and social marketing to promote urgent measures to address climate change. Here the focus is usually on behaviour changes related to energy and emissions via transmission of authoritative, scientifically derived information and facts. Such approaches may be useful and necessary as they can induce a change in human behaviour [5,6••], but there is also the increasing recognition that in a 'post-truth' world of 'alternative facts', there is a need to explore new ways of conceiving, framing, producing and communicating science [7]. Van der Linden et al. [8] suggest, for example, 'inoculating' the public against misinformation through pre-emptively warning people about politically motivated attempts to spread misinformation, a process that requires critical engagement if it is to avoid becoming a new form of social engineering. Modes of knowing such as critically reflexive engagement with scientific knowledge, that science may not always easily illuminate, thus also need fair and urgent consideration as we strive to face the challenge of climate change [3,9].

Given the notable climate events of 2017 (e.g. devastating hurricanes, whose attributions coupled to climate change are still being examined) the notion of a 'new normal' for current climate is being debated (for example, recent Water Research Commission in Johannesburg, 2017). Next to seeing the 1.5 degree C target as a technical target [2,5,6••], this ambition can also be perceived as a metaphor to indicate fundamental changes needed in personal belief systems, values, structures, and ways of organising societies and economies. Such an approach can

surface difference in perspectives, and highlight the synergies, contradictions, controversies and conflicts inherent in climate change debates. This calls for social engagement [10], and in some instances, for the exploration of alternative ontologies and lifestyles [11•]. A shift from facilitating changes through optimisation towards reflexively learning to understand differing views, perspectives, cultures and ways of approaching climate change can begin to point to those areas requiring personal and societal transformation [12•,13]. These expanded paradigmatic approaches are gaining much traction (e.g. recent Resilience Conference in Stockholm, September 2017; Transformations Conference in Aberdeen, September 2017). In this paper we note this expanding reflection but focus much of the paper on the role that education and learning can play in building capacities for critical thinking, reflexivity, systems thinking, collaboration, collective agency and transformative practice [12•].

Methodology and framing the review

Engeström et al. [14] argue that most research on learning is conducted in formal educational settings. In the context of 'wicked problems' [15] such as climate change, however, more learning research is needed in real-world situations and informal contexts [11•]. Following this line of thinking, this review covers formal, as well as organisational and informal learning contexts in a multi-disciplinary 'melting pot' of research from the learning sciences [1••,11•,12•,13,14,16–19], transition sciences [6••,10,20,21], and environmental and climate sciences [4,5,22,23,24,25••,26,27,28•].

Common keywords were used in the literature search (climate change, education (social) learning, sustainability, transformation, transition) across the search engines of Scopus, Web of Science, and Google Scholar to identify articles that were drawn from the multidisciplinary fields outlined above. We particularly sought to identify those papers focussing on meta-theoretical and large-scale studies, global perspectives, and paradigms of thinking associated with learning and climate change that have been produced in the past seven years (2010-2017). The papers selected address the climate change/education and learning interface directly or have direct relevance to this focus. We then differentiated the selected papers for their different approaches and learning orientations. In the context of this paper we have used 'learning orientations' to indicate the contextual dynamics that shape learning, and also the purposes that drive the orientations. For example, a policy orientation would indicate that the learning is oriented *mainly* towards policy implementation. We also found that the contextual dynamics were shaped by diverse institutional settings, for example organisational learning is shaped by more formal organisational settings, while traditional science-based learning is shaped by the history of science education that emerged in formal education settings. Policy oriented learning is shaped by policy imperatives, and transformation/transition oriented learning appears to shaped more loosely by a diversity of less structured learning environments and histories, but most often foregrounded the need for multi-sector and multi-actor engagement. Through an iterative process we mapped out the papers in relation to these contextual settings and histories.

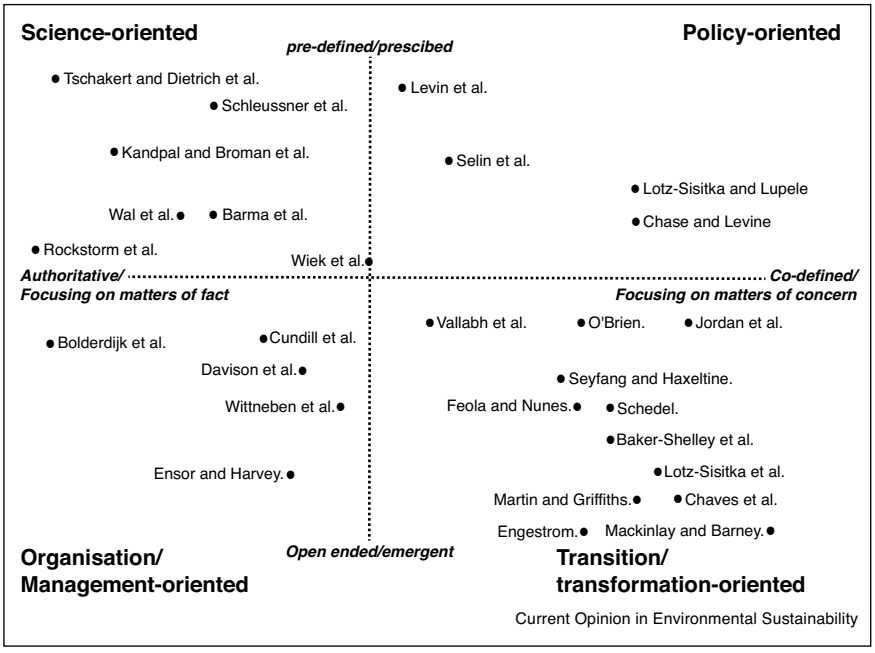
We then adapted Jickling and Wals' [29] well-cited heuristic for classifying emancipatory and instrumental forms of learning within the sustainability context, drawing also on Dillon et al.'s [30] interpretation, and through iterative engagement with the selected papers, we identified and mapped out four orientations to climate change learning, namely: science-oriented [5,6••,16,22–24,31], policy-oriented [17,18,20,21], organisational/management-oriented [19,25••,32,33,34••]; and wider social transformation/transition orientations [11•,14,26,27,28•,35–37,38••,39–41]. This allowed us to position the papers (see Figure 1), within a 'force field' heuristic, whereby two dotted lines distinguish the field within which the centre of gravity of each of the four orientations falls. Those lines, however, are not meant to divide the orientations, but rather to provide a way of considering different orientations to learning, as well as how they may relate, and what their particular contributions can be to climate change and learning. As a final step, based on the papers reviewed, we distilled the characteristics and conditions needed for supporting change on the road to 1.5 degrees C associated with each of these orientations.

Analysis of climate change learning as shaped by diverse learning orientations

If considered in more depth, the heuristic mapped out in Figure 1 displays a continuum of learning theory research, ranging from more behaviorally oriented to more inclusive and transformative modes of learning that emphasise reflexivity, capacity-building and competence. The juxtaposition in Figure 1 between predefined/prescribed and open/emergent learning approaches, as well as the division between authoritative learning approaches focusing on matters of fact (where we know what needs to be done and how to act with relative certainty) and participatory learning focusing on matters of concern (where we have a hunch but do not know for sure and need to engage people in a co-creative quest), allows for a more nuanced view of this continuum. It also allows for inclusion of approaches to climate change learning that include debate and deliberation about the kinds of changes required.

Each of the learning orientations tend to show specific motives, approaches and learning-related issues that are helpful to consider on the pathway to 1.5 degrees C. Hulme [3] notes that there are multiple, creative applications of the idea of climate change; applications that do not necessarily require agreement, as they "thrive in

Figure 1



A heuristic for analysing learning orientations and learning approaches. Adapted from Jickling and Wals [29] and Dillon et al. [30].

conditions of pluralism and hope, rather than in conditions of universalism and fear" (p. 363). This is not, however, a license for climate denialism, but rather an encouragement for engaging in deep and critical debates on how to address climate change and transform societies towards a less destructive, more socially just condition. Thus, it is in this sense that we also propose that rather than seeing the quadrants as distinct views, the idea is that multiple approaches (with blurred boundaries) may be needed if we are to begin to effectively address climate change, and if learning is to allow for engagement with the deep cultural and social-ecological rifts that have created the conundrum that climate change presents. Additionally, we recognise that none of these orientations on their own will 'solve' climate change, but rather that there is possibility of movement and transformative orientation towards 1.5 degrees C within all of these orientations. In the next section, we discuss each of these orientations from this perspective.

Science-oriented learning

The papers clustered into this quadrant tend to follow a fundamental assumption that scientific and technical knowledge can drive change, in the main reflecting an instrumental approach characterised by a 'transmission mode' [29]. In this form, knowledge of scientific facts about climate change is transferred to learners, with confidence in the knowledge and the course of action to be taken. There is an explicit urgency associated with the need to be clear about what forms of science and technology are needed for 'driving' rapid behavioural change as argued by scientists such as Schleussner et al. [31], and Rockstrom et al. [5], amongst others. One form is through anticipatory learning which, as argued by Tschakert and Dietrich [23], involves forward-looking learning processes that enhance adaptation and resilient livelihood pathways. Another is citizen science including the evaluation of a human–computer interface that provides feedback to citizen scientists reported by Wal et al. [22]. Yet another is renewable energy education which primarily seeks to provide functional knowledge of facts, concepts and technologies for strategic use of more renewable sources of energy [6••].

However, there are also researchers that recognise that not all of the science associated with climate change is certain, and this brings traditional transmission approaches into question. Wiek et al. [24] note the need for more emphasis on collaborative learning including actors outside of academia, as well as actionable change, while also emphasising the importance of systems-based scientific knowledge. Barma et al. [16] show that the uncertainties associated with climate science creates complex challenges for educators. They argue that pedagogical, epistemological and cultural 'adjustments' or transformations are required in formal science education if the nature and scope of climate science is to be fully engaged and accommodated [16]. It produces challenges for educators' transformative agency to change the way education and learning is approached. As argued by Rapley

et al. [7], an example of this could be through innovative forms of communication with more of a focus on conveying the meta-narrative of climate change through personalised stories and dialogue.

Policy-oriented learning

The papers clustered into this quadrant tend to foreground the importance of learning as a means of enhancing policy implementation for achieving change. Here key policy drivers for climate change responses are mitigation, adaptation and resilience approaches. In this literature, emphasis is placed on direct transmission-based learning, but also on reflexivity expressed in the discourse of triple loop learning [25••] and anticipatory learning [23]. Recent growing interest in transdisciplinarity of science building on the work of Gibbons and Nowotny [42] as a mechanism for policy implementation, is expanding the learning arena to include actors across a broad spectrum — working not *for* but *with* society [24]. Learning is therefore not only transfer-oriented with a linear policy focus, but includes a number of iterative learning cycles with a variety of practitioners. This shifts the focus from the science-policy interface to a science-policy-practice interface.

Proposing another form of policy engagement via learning, Selin et al. [18] argue that policy literacy is an important complement to climate science literacy, and that combining the two in education will equip future scientists to cross the boundaries between science and policy. Here the focus is on learning how to use scientific knowledge in policy decision-making. Such processes are accompanied by negotiation, decision-making, communication, participation and management skills, especially for scientists [6••]. This can be compared to Levin et al. [21] who describe a more instrumental approach to dealing with 'super wicked' problems, which comprises path-dependent policy interventions with potential for wider social constraint.

Policy-oriented approaches to learning affecting climate change are also found in educational policy literature, where discourses driving concepts of quality education tend to focus more on efficacy and inclusivity than on linking local and global concerns, even in Education for Sustainable Development policy [17]. In response, Lotz-Sisitka and Lupele [17] argue for considering 'learning as connection' with society and environment as a key quality criterion in formal education settings. This has significant impacts on the possibilities for learning-centred responses to the 1.5 degree C agenda in the formal education system.

Organisational and management-oriented learning

The papers clustered into this quadrant tend to foreground the need for learning as a means of achieving organisational mandates or management objectives, which in turn can contribute to change. Cundill et al. [25••] focus mainly on the role and significance of learning in building social-ecological system resilience in natural resources management contexts. They argue that because social-ecological systems are complex and changing, social learning is necessary for the management and resilience of natural resources. This type of learning seeks changes in social units and changes at multi-levels [25••,43].

Organisational learning related to climate change also involves employees in organisations monitoring their own impact or performance (intra-agency learning) with regards to environmental management or carbon emissions. In such contexts, there may be differences in the degree to which the employees participate in setting the objectives of the monitoring taking place [33], which has implications for the learning potential of such practices.

Wittneben et al. [32] note that climate change is also a "political issue where a variety of organisations state agencies, firms, industry associations, NGOs, and multilateral organisations engage in contestation as well as collaboration over the issue" (pg. 1). The work of Kristjanson et al. [44] and Ensor and Harvey [34••] points to the importance of giving attention to inter-agency and institution-based social learning for transitions to sustainability.

In the context of organisational social learning and climate resilience, Cundill et al. [25••] point to a need for further research to better understand types of learning (e.g. recursive loop learning and social learning), better integration of divergent knowledge systems, and better combinations of knowledge creation, monitoring and learning. More widely, Ensor and Harvey [34••] point to the need for social learning research at the intra- and inter-agency level in sustainability transitions.

In the education system, building capacities for institutional change can in turn also foster innovation in teaching and curricula. Davison et al. [19] show how the development of a distributed leadership model among educational institutions and teachers has led to the development of an interdisciplinary and collaborative climate change curriculum and pedagogy leading to student empowerment. This again points to the importance of multi-levelled, intra- and inter-agency, as well as interdisciplinary orientations to organisational learning on the pathway to 1.5 degrees C.

Transition and transformation-oriented learning

The papers clustered into this quadrant tend to follow the assumption that fundamental changes are needed in our society, at the level of beliefs, values, actions and societal structures. They foreground the complexity of learning in multi-voiced, inter- and transdisciplinary or social movement formations. In such education and learning contexts, it is not possible to deal with 'facts only' [14,45]. This requires engaging more with 'matters of concern' [41]

in more open-ended, political and value-laden ways in and amongst wider social movements and inter-sectional communities (see [46]), in ways that are oriented towards 'deliberate transformation' [28•]. Here ethics, decolonisation, well-being and sustainability become some of the orienting narratives for transformative learning.

There is a recognition that learning in this quadrant involves various dimensions of transformation — personal, practical and political [28•], and societal [34••,45]. To avoid falling into a trap of behavioural indoctrination or social engineering [37], such education and learning needs to be constituted as open, co-engaged and more radically transgressive processes of reflexive change [11•,14,37,47]. Baker-Shelley et al. [39] address this transformation in higher education from a whole system institutional approach and discuss the need for systemic change at different micro, meso and macro levels within academia. Jordan et al. [40] emphasise the importance of collaborative science around local issues and engaging in iterative, collaborative, and adaptive learning, and Vallabh et al. [41], articulate different 'epistemic cultures' required for citizen science education that embrace social learning and social justice paradigms.

Schudel [37], building on Bhaskar [48], argues that such processes of learning involve engaging with what is present and known, what is not present, what *could* be, what *should* be, and what *can* be. This is reinforced by Mackinlay and Barney [36] who address emergent and 'unknown' matters of concern in decolonisation processes involving ongoing questioning of assumptions associated with social justice and praxis.

These approaches to learning tend to foreground individual and collective (relational) forms of agency [35], and criticality, new forms of ontological politics [11•]. Martin and Griffiths [35] address the forms that change takes, arguing that there is a need to guard against transformation being at the expense of more marginalised social groups. Engeström does not consider learning as primarily 'cognitive expansion' but rather as a mechanism " . . . to produce new material objects, practice and patterns of activity" (pg. 9), involving transformative agency [1••,14,37,45].

Within the 1.5 degrees C pathway, a great challenge in transformative based learning is to mainstream it into the wider education system [24]. As Seyfang and Haxeltine [26] note, there is a strong emergence of community-based governing of sustainability transitions, operating in connected action-oriented learning networks. However, as Feola and Nunes [27] note from a transition town movement perspective, scaling up initiatives is complicated, and the impacts on climate change uncertain, hence the response from some social learning theorists to focus on intra, and inter-agency social learning at diverse levels [34••].

Discussion

The multi-disciplinary range of articles from this review all contribute in their own way to developing a more expansive understanding of climate change, with an emphasis on learning. More pre-determined and instrumental approaches to addressing human behaviour co-exist with more emancipatory and emergent approaches, with associated desires for different kinds of change [30,49]. In our review it was notable that there are many recent works emerging in the wider transformation 'quadrant', as people seek ways of creating a reflexive learning society capable of dealing with the deep seated cultural rifts, risks and uncertainties that characterise climate change.

The orientations reviewed all show 'movement' on the path to 1.5°C, albeit in slightly different ways. Overall, and important for progressing climate change related learning in a transformational context, is the need to make interests and purposes of learning more explicit:

- The science-oriented learning of the top left quadrant provides an authoritative basis in 'matters of fact' which can help anchor climate change debates in measurable/proven scientific terms. For such learning to be transformative in addressing denialism and post-truth politics, however, more innovative forms of communication [7] and accountability in what comes to be regarded as scientific 'fact' [9] are needed;
- The top right cell capturing policy-oriented learning directs learning at the collective scale, providing a 'roadmap' [5], which can be used to plan and to implement national and international collaboration and policies. The increasing focus on transdisciplinary research can be seen as a move towards more open-ended and potentially transformative policy-oriented learning outcomes [24,42];
- The bottom left management and organisation-oriented learning emphasises the relevance for organisations and businesses to organise themselves to address challenges such as climate change at intra and inter-organisational levels. Such multi-level approaches which appreciate the role of social learning demonstrate the transformative nature of this approach to learning [25••,43];
- Finally, the lower right transition/transformation-driven learning focuses on the role of learning in more emergent, reflexive and open system environments [38••] with a strong focus on including multiple actors. Here there are signs of learning processes that can open up and foster dealing with conflict, cultural rifts, transgressions across boundaries and between world views, belief systems and institutions showing these as potentially important learning processes on the path to 1.5 degrees C [11•,35,36,38••].

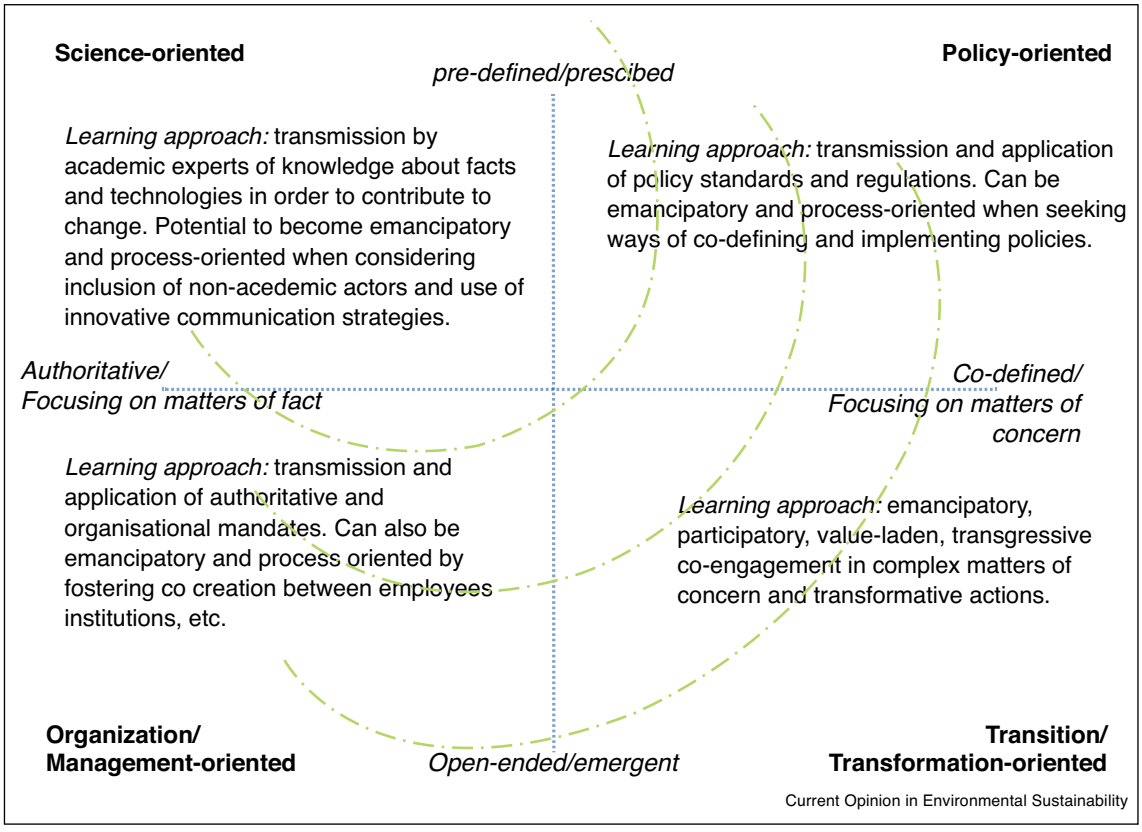
When working with heuristics it is important to keep in mind that reality is much messier than what heuristics

tend to reflect. The analysis of literature in this review suggests that, while all orientations of learning can contribute to change, the learning motives and approaches usually become more expansive, more inclusive and more complex, when moving from the upper left area towards the lower right. This is represented by the expansive 'waves' in Figure 2 below. The analysis also indicates that different learning orientations may co-exist in the same capacity building setting or learning program. In turn, this suggests that the areas of the quadrants are not mutually exclusive. For example, policy-oriented learning may include the relevance of science as is the case with the IPCC process, where a wide range of both science and increasingly, various approaches to information transmission and learning for transformative adaptation is encouraged [2]. Or for example, from an organisational-oriented perspective, one can enhance innovative organisational arrangements focusing on collaborative curriculum development among institutions and teachers [19]. Last, a transformation-oriented approach can emphasise the need for inclusiveness and co-production of actionable knowledge, which requires making use of authoritative forms of scientific knowledge together with 'other' forms of knowledge [39].

The fundamental differences infusing underlying assumptions among the learning drivers may also lead to tensions. Typically the language used in some climate change arenas relates to trade-offs and synergies, instrumentally calling for a change in behaviour. Even a strongly optimising, technical approach in the form of a "carbon law" [5] can be interpreted as a continuation of the status quo, based on the assumption that there is nothing fundamentally wrong with the growth mantra or the neo-liberal agenda. This can lead to a tension which is difficult to reconcile between *adapting* towards a 1.5 degree C world through anticipatory learning [23] and the need for *disrupting* the status quo through more 'deliberate transformation' [28•] or 'transgressive learning' [11•,38••].

In some cases, rather than smooth transitions and discernable pathways to change, there may be a need for more disruptive, deliberative, and even transgressive transformations on the pathway to 1.5°C. In this light, Wals and Peters [50] note the importance of critically addressing our inbuilt cultural narratives and embodied ontological pre-dispositions, so as not to be blinded by alternative ways of 'seeing' and 'being' that may be more generative for sustainability. While there are some niches in all four

Figure 2


Science-oriented
pre-defined/prescibed
Policy-oriented
Learning approach: transmission by academic experts of knowledge about facts and technologies in order to contribute to change. Potential to become emancipatory and process-oriented when considering inclusion of non-acedemic actors and use of innovative communication strategies.
Learning approach: transmission and application of policy standards and regulations. Can be emancipatory and process-oriented when seeking ways of co-defining and implementing policies.
Authoritative/
Focusing on matters of fact
Co-defined/
Focusing on matters of concern
Learning approach: transmission and application of authoritative and organisational mandates. Can also be emancipatory and process oriented by fostering co creation between employees institutions, etc.
Learning approach: emancipatory, participatory, value-laden, transgressive co-engagement in complex matters of concern and transformative actions.
Organization/
Management-oriented
Open-ended/emergent
Transition/
Transformation-oriented
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Learning orientations and approaches for change and transformation. Adapted from Jickling and Wals [29] and Dillon et al. [30].

learning approaches reviewed here that represent a more radical shift towards transformative orientations, they are somewhat difficult to find and may also be contradictory and in tension with each other (e.g. [2]). Here it is helpful to consider the advice of learning scientist Engeström [14] who suggests that tensions and contradictions are both helpful and important for *expanding learning* and change in human activity, and must therefore be confronted and embraced, not rejected.

Conclusion

This review has shown that diverse orientations to learning exist that address climate change concerns via a mix of instrumental and emancipatory approaches in various contexts. All of the papers reviewed here cohere around an interest in education and learning for societal change, with growing tendency towards more transformative social learning based on dialogue between diverse actors in open systems. This does not negate the importance of learning in other contexts, such as formal science education, policy engagement, or organisations. As shown across the papers, learning in all these contexts must be grounded in reflexivity and engagement with high quality knowledge that is derived from various ways of 'knowing', including science knowledge. This can be greatly helped through being inclusive, recognising multi-voiced perspectives, and enabling transformative agency to emerge at multiple levels. As shown via the heuristic, such 'knowing' resides in various contexts, including in formal education settings amongst the world's teachers, in organisations (intra- and inter agency settings), in multi-levelled policy contexts, and in social movements and wider social learning settings.

Assuming there remains some optimism in terms of reaching the 1.5°C target (see [51]), there is by now a consensus that profound and far-reaching sustained change will be necessary to accomplish this. Moving from the top left quadrant towards the bottom left quadrant — from technical approaches and often pre-prescribed solutions towards emergent and multi-perspective approaches — appreciates that rather than quick technological fixes, transitions towards more sustainable futures takes time, contestation and negotiation, but in the end can help address the root causes of climate change and eventually profoundly contribute to curbing global warming.

References and recommended reading

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- •• of outstanding interest

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